

Management of renal and ureteric stones

Renal calculi

Natural history of renal calculi

Glowacki 1992 (n=107)

32% episode of renal colic within 2 yrs

50% symptomatic within 5yrs (10% per yr)

Hubner 1993 (n=63) 7 year outcomes:

45% increased in size

70% symptomatic

40% required surgery

Burgher 2004 (n=300)

77% increased in size

26% required intervention

Renal calculi

In general

Upper/mid poles

< 1cm

ESWL

FURS

1-2cm

ESWL

FURS

> 2cm

PCNL

ESWL with stent

?FURS

Lower pole

< 1cm

ESWL

FURS

1-2cm

FURS or ESWL or PCNL

> 2cm

PCNL

Lower pole calculi (Raman and Pearle 2008)

Data from Glowacki and Burgher (above) demonstrate that 'asymptomatic' lower pole stones increase in size under observation and become symptomatic in 25-50% of cases

ESWL not without its complications however, and risks and benefits should be carefully weighed in each case

Management options comprise ESWL, FURS and PCNL

(i) ESWL

Factors affecting efficacy of ESWL

Stone size clearance inversely prop. to stone size

Composition

Location

Anatomy*

?Body habitus**

*Anatomical factors

Infundibular length, width and infundibulopelvic angle

If angle < 70 degrees, length > 3cm or width < 5mm clearance rates reportedly < 50% (Bumino 2002)

****Skin-to-stone distance >9-10cm a/w reduced efficacy of ESWL**

Outcomes

Meta-analysis of 2927 patients at 13 centres (Lingeman 1994) showed ESWL to be less efficacious than PCNL (59% vs. 99% respectively). Results of ESWL:

90% clearance for upper and mid-pole stones

59% clearance for lower pole stones. Of these;

<= 10mm 74%

11-20mm 56%

> 20mm 33%

Lower Pole Study Group 1 (Albala 2001) prospectively randomised 128 patients with stones up to 3cm to either ESWL or PCNL. Overall stone clearance 37% for ESWL vs. 95% for PCNL. Results of ESWL:

<10mm 63%

11-20mm 23%*

21-30mm 14%*

*** Very poor results for stones >10mm.** Discrepancy with Lingeman et al may be explained by the observation that many studies in Lingeman's meta-analysis were sponsored by lithotripter companies

Some recent evidence that stone-free rates improved with adjuvant PDI therapy (percussion, diuresis (500ml fluid) and inversion) Chiong 2005

(ii) FURS

Contemporary stone free rates 60-80% reported

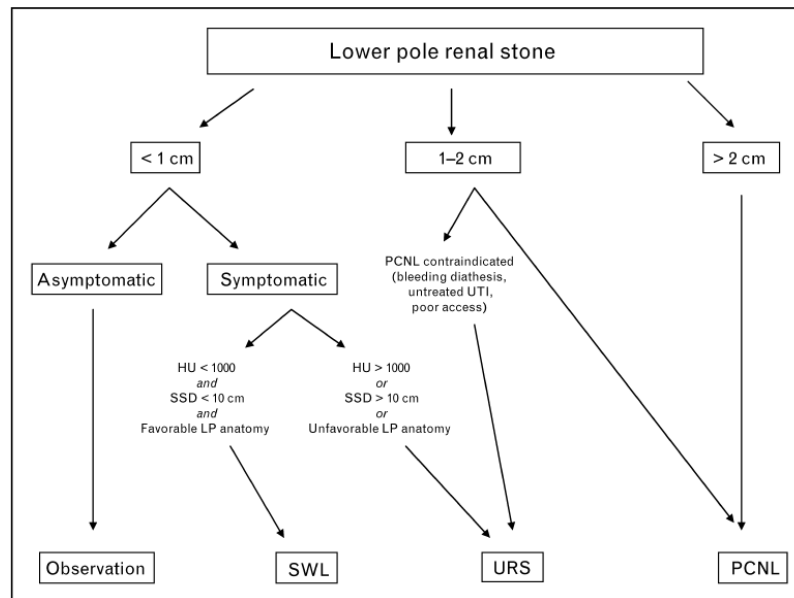
Lower Pole Study Group randomised stones < 1cm between FURS and ESWL (50% clearance vs. 35% respectively but low power and non-significant)

Lower Pole Study Group randomised stones 1-2.5cm between FURS and PCNL (37% clearance vs. 71%) – surprisingly no difference in convalescence but patients stented in FURS group

(iii) PCNL

Stone-free rates 95% (100%, 93% and 86% for stones <1cm, 1-2 cm and > 2cm respectively from LPS1 from Albala 2001)

Generally stones > 2cm in size

Ramon and Pearle treatment algorithmStaghorn calculi

Magnesium ammonium phosphate (coffin lids) and carbonate apatite

May be partial or complete

Natural history of staghorn calculi defined by Blandy and Singh (Published 1976, n=185; 60 patients observed; 125 patients operated) 10 yr mortality was 28% in observation group (cancer in 4, pyonephrosis in 16) vs. 7% in operated group. Retrospective study – problem with selection bias.

Recently updated by Teichmann et al 1995; n=177, 30% renal deterioration, 3% mortality in partially cleared group vs. 67% in refused treatment group.

Overall unRx leads to ~50% delayed nephrectomy rate for sepsis

Complications of PCNL

- Infection*
- Haemorrhage
- Pelvic perforation
- Renal colic
- AV Fistulae
- Pneumothorax**
- Hydrothorax**
- Injury to adjacent viscera***
- Residual stones****

* Best predictor of organism causing post-PCNL sepsis is stone culture or intra-operative renal pelvic urine, NOT pre-op MSU.

** A/w upper pole puncture; always perform in full expiration

*** Most commonly in thin female patients with retro-renal colon.

**** Recurrence rates after PCNL related to adequacy of clearance

Total clearance 10% recurrence

Partial clearance 23% recurrence

What's new in PCNL?

- Supra 12th rib access
- Tubeless (stent or truly tubeless)
- CT info and skin-stone depth
- 3D CT reconstruction
- Mini percs
- Flexible instrumentation

Are residual fragments(<4mm) important?

Yes

- On follow-up 40-60% patients demonstrate stone growth or symptoms*
- ~25% become stone-free and 25% stay the same
- * lower for children ~33%

Open surgery

Still has limited role; large centres report 1-5% open surgery rate

Indications for open surgery:

- Complex stones
- Treatment failure with PCNL
- Morbid obesity
- Concomitant open surgery
- Partial or complete non-functioning kidney
- Stone in inaccessible transplanted/ectopic kidney

Options for open surgery

- Pyelolithotomy
- Pyelonephrolithotomy
- Anatrophic nephrolithotomy
- Partial nephrectomy
- Pyeloplasty and pyelolithotomy
- Ureterolithotomy
- Ureterolithotomy and ureteroneocystotomy

Ureteric stones

Acute ureteric colic

Aetiology

- Passage of renal calculi
- Blood clot
- Tumour
- Sloughed renal papilla

Diagnosis

- Flank pain 40-70% PPV
- Haematuria 60% PPV; 85% sensitivity
- Plain film 50% sensitivity all-comers; 70% radiologists
- USS 50% sensitivity
- IVU 80% sensitivity; 90% specificity
- CT **95% sensitivity; 95% specificity**

CT features of obstruction

- Hydronephrosis 80% sens.
- Hydroureter 80%
- PN stranding 50%
- Renal swelling 60%
- Periureteric rim 60%

HU can indicate hardness of stone

Range 250 – 1000 HU generally

Uric acid stones ~350

Calcium oxalate ~ 650

Cystine ~ 900 +

However high degree of overlap and HU alone have not been shown to predict response to ESWL

Recent evidence suggests that HU<900 and skin-to-stone distance of <9cm predicts successful ESWL in >90% (Perks 2008)

Management

Conservative vs. intervention (ESWL vs. rigid URS)

Likelihood of passage related to location and size (EAU)

< 4mm diameter - more than 80% chance of passage

< 7mm

Proximal ureter - 25%

Mid ureter - 45%

Distal ureter - 70%

Two thirds pass within 4 weeks (Hubner 1993)

(i) Conservative management

Analgaesia

Diclofenac more effective vs. opiates in acute phase

Diclofenac 50mg tds prevents recurrent pain in patients managed conservatively

No evidence that NSAIDs impair renal function in patients with normal renal function

Medical expulsive therapy

Remains controversial

Detrusor and distal ureter = alpha-1d receptors

Tamsulosin most selective for alpha 1a and 1d receptors.

No evidence of benefit for tamsulosin vs. other alpha-blocker

Hollingsworth metaanalysis (Lancet 2006) **65% greater**

chance of stone passage with alpha blocker* than

controls. Potential small benefit for additional steroid

therapy. NNT = 4. Duration of therapy = tamsulosin 0.4mg for 28

days. However, tamsulosin not licensed in UK for MET

Recent randomised controlled trial by Hermanns 2009 (n=100)

showed no difference in passage (87% for tamsulosin, 89% for

placebo) although reduced analgesia and earlier stone

passage in tamsulosin group.

SUSPEND (spontaneous urinary stone passage enabled by

drugs – Sam McClinton from Aberdeen) is a UK PC-RCT

currently recruiting patients to either placebo, calcium channel blockers or alpha-blockers

Contraindications to conservative therapy

Stone > 7mm diameter

Uncontrolled pain

Infection

Obstructed solitary kidney

Bilateral obstruction

(ii) Intervention for proximal ureteric stones

a) ESWL

Level of stone in the ureter	No. of patients	Stone free % (range)	Auxiliary procedures %	Anaesthesia %	Re-ESWL %
Proximal (30 reports)	8,825	77.4 (63-100)	13.0	11.3	10.0
Mid (24 reports)	429	80.3 (60-98)	4.3	4.3	8.2
Distal (38 reports)	6,896	77.9 (59-100)	12.9	11.1	9.4

Overall EAU found 81% stone-free rate with 12% re-treatment rate.

Very similar to large US study using Siemens lithostar (Mobley 1994;

stone-free rate 84%, retreatment rate 11%

b) URS (% stone-free rates)

	<1990	1990-1995	1996	1999
Renal	ND	96	ND	76-91
Ureteral				
UU	50	95	96	98
MU	62	69	91	99
LU	95	61	93	98

Results for ureteroscopy have shown a dramatic improvement over the last 10 years, such that > 97% patients rendered stone-free with URS. Moreover ~ 95% require only one treatment
Results compare favourably with ESWL, but requires GA and more morbidity than with ESWL

Steinstrasse

Defined as stone burden >5cm in length

Typically after ESWL

- 1% overall

- 5% stones > 2cm

- 40% following ESWL for staghorns

URS preferred modality; exception is for large leading stone which may be amenable to ESWL

Stenting does not reduce the likelihood of steinstrasse

PCN vs. nephrostomy for acute decompression?

No clear consensus

Postal survey of UK Radiologists and Urologists (BJMSU) organised by Section of Endourology

- Ureteric obstruction with sepsis

 - Urgent nephrostomy preferred. Stent preferred for uncorrectable coagulopathy

- Ureteric obstruction for acute renal failure

 - Semi-urgent de-obstruction. 50:50 nephrostomy vs. JJ stent

 - Nx has advantages – allows antegrade study, obviates need for anaesthetic in patients with new biochemical/cardiovascular abnormalities

2 x randomised trials of PCN vs. JJ stent; Pearle 1998 and Mokmalji 2001. No difference in recovery between two, although reduced duration of Abx Rx in nephrostomy group and Mokmalji reported a 20% failure rate for stenting

Stenting for malignant ureteric obstruction?

Must determine whether will lead to reasonable duration of good quality life

4 categories (Watkinson criteria)

1. non-malignant complication
2. unRx malignancy
3. relapsed disease with treatment options
4. relapsed disease with no treatment options

Stenting advocated in 1, 2 and 3. Give patient options in category 4 (However overall survival 38 days after nephrostomy with many not leaving hospital)

Extrinsic ureteric obstruction due to malignancy a/w only 50% patency rate at 3 months

Options:

- Large bore stents (8F)

- 2 stents

- Memocath short stenting

- Metallic full length stenting

- Extra-anatomical stenting

Stones in pregnancy

90% women develop hydronephrosis in pregnancy

Due to compression by fetus and effects of progesterone on ureter

Right > left (sigmoid thought to be protective)

Renal colic no more common in pregnancy than in non-pregnant women

Although pregnant women hypercalciuric and hyperuricosuric with increased urinary stasis, urinary inhibitors and GFR increased, offsetting risk

Management considerations

75% stones will pass spontaneously; 25% will require intervention

Calculus associated sepsis a/w pre-term labour

Persistent obstruction a/w risk of permanent renal impairment

Fetal radiation dose < 1 milligray (AXR/MAG3) a/w tiny increased risk of childhood cancer

Fetal radiation dose > 1 milligray (IVU/CT) a/w 2-fold increased risk of childhood cancer

Effects of unenhanced MRI in pregnancy unknown

No evidence of pre-term labour for general anaesthetic alone

Ureteroscopic stone extraction may be performed safely in first and second trimesters

Stents and nephrostomies encrust rapidly in pregnancy

Management recommendations

Trial of conservative therapy advocated in most patients

If fails to settle, unenhanced MRI preferred imaging modality

First and second trimesters

Stone < 1cm stent/PCN or primary URS

Stone > 1cm stent/PCN

Third trimester

Any stone size stent/PCN & Rx post-partum
induce

Appendix

Assessment of stone size

Diameter

Surface area

$$SA = l \times w \times \pi \times 0.25$$

Volume

$$Vol = SA \times 0.6$$

Radiation exposure

Gray absorbed dose

measured in joules/kg

Sievert attempt to quantify the biological effects of radiation [1Gy to bone is not same as 1Gy to small bowel]. Also known as dose equivalent

measured in J/kg

Gray x Q x N where Q = type of radiation, and N = type of tissue, volume of radiation and time of exposure

CXR 0.02 mSv

MAG3 0.4 mSv

KUB 0.5 mSv

DMSA 1.0 mSv

3-film IVU 1.5 mSv

6-film IVU 2.5 mSv

CTKUB 4.7 mSv

CTU 10 mSv

Annual background radiation 2-3 mSv

Annual occupational limit for effective dose = 50 mSv

Lifetime risk of fatal cancer 1 in 5 (20%)

X-ray dosage of 10 mSv increases risk by 1 in 2000 (0.05%)

Contrast administration

All contrast agents have a 2,4,6-tri-iodinated benzene ring.

Type of molecule at position 1 important: carboxyl group = ionic dissociation (high osmolar contrast media); hydroxyl group = water soluble (low osmolar contrast media)

Allergy, anaphylaxis, renal failure and lactic acidosis important side effects of contrast administration

Side effects 5-10 x higher with high osmolar (ionic) contrast media

Increased risk of severe reaction in patients with history of severe allergy, asthma (6x),

(i) Allergy

Flushing, rash, oedema

2-4% of patients

Treat with antihistamine (chlorpheniramine 10mg PO/IV) +/- IVI and steroids (100mg hydrocortisone IV)

History of allergy not a contraindication to further contrast.
 However, ensure only LMW non-ionic contrast and pre-treat with steroid (6 hrs prior) and antihistamine (1hr prior) [NB. no evidence of benefit of steroids however]

No increased risk of allergy in patients with shellfish allergy

(ii) Anaphylaxis

Laryngospasm, hypotension, tachycardia, cardiac arrest

Fatal reaction 1:100,000

Immediate management

Sit up

Oxygen

IV fluid bolus

0.5 mg adrenaline IM (RCR guidance)

10mg chlorpheniramine IV

100mg hydrocortisone IV

Call anaesthetist

Reaction	Ionic contrast media 1200 mosm/l	Non-ionic contrast media 600 mosm/l
	e.g urograffin	e.g niopam/omnipaque
Non-fatal allergic	1:50	1:250
Life-threatening	1:500	1:2500
Fatal anaphylactoid*	1:100,000	1:100,000

* Thought to be an overestimate: US FDA reports 1:1,000,000 administrations.

NB. anaphylactoid is correct term, not anaphylactic because not IgE mediated

Number after contrast media (e.g. Niopam 200) indicates amount of iodine (mg/ml)

(iii) Renal failure

Defined for radiological purposes as serum creatinine \geq

130 μ mol/l

Contrast induces afferent arteriolar vasoconstriction leading to tubular ischaemia

Contrast induced nephropathy defined as creatinine rise of 25% or 44 μ mol in the 3 days following contrast without other cause

Risk groups

Elderly >70

Renal impairment (>140 -150 μ mol/l)

Dehydration

Diabetes

CCF

Concurrent nephrotoxics

Maximum dose of iodine in grams should not exceed the patients estimated GFR

Strategies for preventing contrast-induced nephropathy

Avoid in renal impairment unless absolutely necessary

Stop concurrent nephrotoxics

Pre-hydrate

?N-acetylcystine 600mg bd 24 hours pre-contrast*

Avoid toxic doses of iodine

Avoid repeat administration within 48 hours

* Evidence for NAC controversial. Not currently recommended by Royal College of Radiologists

Long-term outcome of contrast-induced nephropathy

(iv) Lactic acidosis

Contrast administration in patients taking metformin believed to increase the risk of lactic acidosis, especially in those with renal impairment

Mechanism = worsening renal function through mechanisms above lead to accumulation of metformin, which itself a/w lactic acidosis

Current guidelines (RCR 2009):

Metformin is not recommended for use in diabetics with renal impairment, because it is exclusively excreted via the kidneys. Accumulation of metformin may result in the development of the serious complication lactic acidosis. Although the incidence of lactic acidosis following contrast administration in diabetic patients receiving metformin appears to be extremely low, extra care should be exercised in these patients [9].

Advice

- *If the serum creatinine is normal, and a low volume of contrast agent (up to 100 ml) is to be administered intravenously, no special precaution is required.*
- *If the serum creatinine is normal, but more than 100 ml of contrast agent or the intra-arterial route is to be used, metformin should be withheld for 48 hours after the procedure.*
- *If the serum creatinine is raised, the need for the contrast agent should be re-assessed. If contrast injection is deemed necessary, metformin should be withheld for 48 hours before and 48 hours after the contrast is given and the renal function re-assessed before restarting the metformin treatment.*

(v) Untreated hyperthyroidism

Contrast administration not recommended until disease treated

Ionising radiation and pregnancy (RCR guidelines 2009)

Fetal death, malformation, growth retardation and severe mental retardation require doses over 100mGy; normal radiological procedures never exceed such a dose

Advice

The radiation dose to the embryo or fetus that is likely to result from any diagnostic procedure in current use should present no risk of causing fetal death, malformation, growth retardation or impairment of mental development.

Risk of childhood malignancy with fetal radiation exposure. Risk increases proportional to fetal radiation dose. No safe time after first 3-4 wks of pregnancy

Childhood cancer risk

Normal baseline risk	0.2%	(1:500)
Fetal radiation exposure \leq 1mGy	0.21%	(1:475)
Fetal radiation exposure $>$ 5 mGy	up to 0.4%*	(1:250)

*Oxford survey of childhood cancers found that a fetal radiation exposure of 25 mGy a/w doubling of childhood cancer risk

Advice

For the majority of diagnostic medical procedures, giving fetal doses up to about a milligray (the first three groups in the table), the associated risks of childhood cancer are very low (less than 1 in 10,000) and judged to be acceptable when compared with the natural risk (of around 1 in 500). Consequently, all such examinations can be carried out on pregnant women, as long as they have been clinically justified and the dose is kept to a minimum consistent with the diagnostic requirements. The very low risks of childhood cancer from these examinations are certainly not sufficient to justify termination of the pregnancy (particularly in view of the associated risks to the health of the mother).

Exposure of pregnant women to the higher dose procedures (the last two groups in the table) lead to fetal doses in excess of a few milligray, and – at the highest doses – may result in a doubling of the childhood cancer risk compared to the natural rate. Consequently, such examinations should be avoided on pregnant women, if this can be achieved without serious detrimental effects to their health. However, if such examinations are considered to be clinically justified or are carried out inadvertently, the childhood cancer risk associated with them is still low in absolute terms (below 1 in 200 and mostly below 1 in 1000) and termination of the pregnancy would not be justified solely on the basis of the radiation risk to the unborn child.